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PROJECT VANGUARD REPORT NO. 2
REPORT OF PROGRESS

Project Vanguard Staff

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14. ABSTRACT

Progress on the Vanguard program continued during January. The Army accepted responsibility for the tracking network pending allocation of the necessary funds, and a preliminary survey has been made of the South American locations. The Army District Engineers are now directing the construction of the launching facilities and assembly hangar at AFMTC. The use of AFMTC has been authorized by the Air Force, which is also providing test range facilities, administrative space, range instrumentation and the launching facilities and hangar being constructed under Army direction. The latter facilities are expected to be ready for the launching of the first test vehicle (Viking 13) in November 1956. Topographical considerations have resulted in the location of the Washington area Minitrack station at Blossom Point, Maryland, rather than the Chesapeake Bay Annex of NRL. The launching vehicle design specification (NRL 4100-1) has been forwarded to the Martin Company. The revised weight and performance parameters provide for an excess velocity margin of 1443 feet per second for a 300-mile altitude. Trajectory and performance studies continue, and first- and second-stage spatial mockups have been released for manufacture. About 50 percent of all major structural design for the first stage is now complete, including the design of dynamic model of the powerplant and tail section. Vehicle instrumentation has been extensively discussed with PAFB and various contractors, and a tentative frequency allocation has been obtained from the PAFB frequency coordinator. The contractors for parallel development of the third stage have been chosen. The satellite configuration has now been established as a 21.5 pound sphere of 20-inch diameter rather than the 30 inches previously considered. Design is being based on a magnesium-thorium alloy, HK-31, which has greater strength and less weight than suitable aluminum alloys. Satellite separation methods are still under study. Contracts have been let for the Minitrack ground antennas, and a general schedule for the development of the Minitrack system has been arrived at. The Minitrack operating frequency of 108.00 Mc and turn-on frequency of 138.06 Mc have been authorized. Development work on transistors and subminiature tubes has been accelerated and two types of satellite antenna are under investigation. A formal proposal for the scientific experiments with the earlier satellites has been submitted to the NAS Technical panel for the Earth Satellite Program. A science program has been presented to the Project Director who has authorized the following: Minitrack system and telemetering development, satellite visibility studies design and development of instrumentation for the Lyman-alpha experiment and for environmental studies, and environmental testing of the satellite and its components. Work is proceeding on these studies.

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The first report in this series is

Project Vanguard Report No. 1, Plans, Procedures, and Progress, by the Project Vanguard Staff, NRL Report 4700, January 13, 1956

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PROJECT VANGUARD REPORT NO. 2
REPORT OF PROGRESS

INTRODUCTION

During the month of January, work proceeded largely along the lines described in Project Vanguard Report No. 1.* Liaison between the Naval Research Laboratory and the various other agencies involved in the program was extended, and trips and discussions clarified a number of problems.

Various plans and specifications have been modified, notably those for the diameter of the satellite and the location of the Washington area Minitrack station. The contract has been let for the Minitrack ground antennas, and the contractors have been chosen for parallel development for the third stage of the launching vehicle. A request for bids to provide electronic computational facilities will be released shortly and it is hoped that these facilities will be available within a month after the signing of a contract. A formal proposal for the scientific experiments to be performed with the early satellites has been submitted to the NAS Technical Panel for the Earth Satellite Program.

This is the second in a series of formal reports on Project Vanguard which will include both technical reports on particular phases of the program and monthly progress reports of a more general nature.

FACILITIES AND COORDINATION WITH OTHER SERVICES

Army

Tracking

The Army has accepted the responsibility for establishing, operating, and maintaining the satellite tracking network, including communications, provided funds are made available. The tracking station near Washington, D. C., and the one to be located on the Island of Barbuda are excluded from this responsibility.

Construction

The Army District Engineers are directing the construction of the Vanguard launching facility and assembly hangar at AFMTC. In addition, they have assumed the responsibility for disassembling at the White Sands Proving Ground, transporting, and re-erecting at AFMTC, the Viking gantry crane for use by the Vanguard Program.

Technical Program

Frequent visits are being made to the REDSTONE Project at the Redstone Arsenal in order that full advantage may be taken of their experience in conducting launching operations at AFMTC.

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*Project Vanguard Staff, "Project Vanguard Report No. 1, Plans, Procedures, and Progress," NRL Report 4700 (Secret), January 13, 1956

Crystal-controlled receivers and DOVAP transponders are being procured from the Ballistics Research Laboratory at Aberdeen Proving Ground. Both the Diamond Ordnance Fuze Laboratory and the Picatinny Arsenal are being contacted for development of a powder-train time delay and a separation mechanism. The Diamond Ordnance Fuze Laboratory is developing an antenna to be extended by an explosive charge for early test. Models of the Vanguard vehicle have been tested in the Ballistics Research Laboratory wind tunnel at Aberdeen Proving Ground by GLMCO and more are planned. Early in the program both SCEL and BRL submitted proposals to undertake satellite tracking and scientific instrumentation. A considerable number of parts and equipments from the Army Hermes program have been made available to the Project Vanguard to assist in the development of the first-stage engine. Discussions have been had with the Office of the Chief of Ordnance concerning types of vans which may be suitable for use with project instrumentation.

Scientific Program

Contact is being maintained between Project Vanguard and the Army Map Service to consider geodetic aspects of the program. The AMS has expressed interest in the simplified Minitrack system.

Air Force

Test Range Facilities

The Assistant Secretary of the Air Force (R&D) has authorized the use of the AFMTC for conducting the Vanguard launching program, and preliminary plans have been made for furnishing the required facilities for this program. A conference is scheduled for 15 March 1956 to finalize detailed design review and to establish readiness dates for the various facilities.

Technical Program

Technical liaison is being maintained through the Air Force Program Officer with the following Air Force agencies:

1. Deputy Chief of Staff (Development), Hq., USAF,
2. Assistant Chief of Staff for Guided Missiles,
3. Western Development Division, USAF Representative, Hq. Air Research and Development Command, Intelligence, Reconnaissance, and Supporting Systems Division

Scientific Program

Liaison with Cambridge Research Center on the scientific aspects of the satellite has been established.

Logistic Support

Test Range Facilities — The test range facilities required by the Vanguard program at AFMTC can be broken down into administrative space, assembly hangar space, range instrumentation, launching facilities, and miscellaneous support. The present status of each is given below.

Administrative Space — Authorities at AFMTC have agreed that suitable administrative space can be assigned to the Vanguard project when required.

Assembly Hangar Space — Adequate funds have been made available to the Air Force to start construction of Hangar S for use by Project Vanguard. A beneficial occupancy data of 1 January 1957 has been scheduled by AFMTC. In the meantime, space in Hangar C will be assigned to Vanguard on an interim basis. An initial occupancy date of 1 July 1956 is being requested.

Range Instrumentation — The status of range instrumentation is discussed in other portions of this report.

Launching Facilities — The launching facilities required consist of a blockhouse and pad, a static-test and launch stand, and a gantry crane.

The initial launching schedule published in Project Vanguard Report No. 1 required the availability of a suitable launching facility by July 1956. It was obvious that this requirement could only be met by the assignment of an existing facility. Since the REDSTONE facility was the only one that could be classed as adequate, an attempt was made to coordinate their launching schedule with the Vanguard schedule. According to the REDSTONE Project Test Director, serious delays would be imposed on other high-priority projects.

The Air Force then proposed that the construction of a new facility be expedited in an attempt to meet the complete Vanguard requirement. At the same time, a careful examination was made of the Vanguard launching schedule to redetermine the launching dates on the basis of more recent information. This resulted in the following mutually acceptable schedule of planning and construction control dates for the new launching complex:

Completion of design criteria; completion of topographical survey of site	15 February 1956
Final review of detailed design plans	15 March 1956
Completion of detailed design; negotiations with selected construction contractors to start	1 May 1956
Actual construction to start	15 May 1956
Section of gantry-crane track to be available; erection of gantry crane to start	15 June 1956
Joint occupancy of blockhouse and pad by contractor and Vanguard engineers	15 August 1956
Gantry crane to be operational	15 September 1956
Operational occupancy of blockhouse and pad by Vanguard engineers	15 October 1956
Launching of first vehicle (Viking 13)	20 November 1956
Permanent water installation to be available for use in conducting static firing tests (adequate temporary water supply can be made available by 1 November 1956 or earlier, if needed)	1 December 1956

The schedule applies to the construction of Launching Complex No. 20, half of which will be used by Vanguard and the other half by another test program. The pad, located 200 feet from the blockhouse instead of the standard 600 feet, is a simplified design to meet the Vanguard requirements.

Static-Test and Launch Stand — The static-test and launch stand required by Vanguard consists of a steel frame structure, fifteen feet high, in which is secured a water-cooled flame duct which deflects the rocket flame through an angle slightly in excess of 90 degrees. This frame is secured to the pad with tie-down bolts. Water is supplied through plumbing connections in the pad. This is a relatively simple setup and will be furnished by the Vanguard contractor.

Gantry Crane — The only practical way of meeting the gantry-crane requirement for the Vanguard launching schedule, timewise, is to move the existing gantry crane at White Sands Proving Ground to AFMTC. An operational date of 15 September 1956 at AFMTC is required. It is estimated that approximately seven months must be allowed for disassembling the crane, transporting it, and re-erecting it at AFMTC. This requires that the re-assembling operation at AFMTC should start by 15 June 1956. The launching-complex construction contractor will be asked to implace a suitable section of gantry-crane track by this date so that the crane erection will not be delayed.

Tracking Network

In addition to launching a satellite into a successful orbit, it is necessary to prove that the satellite is in fact orbiting. This requires tracking the satellite, computing its orbit, and then publishing a predicted path over the various inhabited portions of the earth's surface. The Minitrack system has been designed to provide the necessary information for achieving this objective.

The Army has agreed to assume responsibility for establishing, operating, and maintaining all except two Minitrack stations provided suitable funds are made available. (The two exceptions are the NRL station near Washington, D. C., and the Barbuda station which could be considered part of the initial launching instrumentation requirement.) This assumption of responsibility includes the communication requirement to make the tracking data available to a central collecting and computing agency in the United States.

A preliminary on-site survey has been made by Inter-American Geodetic Survey parties at each of the South American locations. A final site-selection party, including representation from the Army Construction Engineers, the Army Signal Corps, the Vanguard Staff, the National Science Foundation, and the IAGS will start selection of final sites in early March.

The results of this selection will provide a basis for making realistic cost estimates for the complete task. The final site selection, with cost estimates for site acquisition, construction, operation, and maintenance through IGY should be ready during the early part of May 1956.

The Washington area Minitrack test site has been selected and arrangements are proceeding to have it cleared, seeded, and equipped with access roads, trailer pads, power, water, and an operating building. Instead of the Chesapeake Bay Annex, as previously reported, the site selected is at Blossom Point, Maryland, 40 miles due south of Washington—about a one-hour trip from NRL. This location was chosen because a sufficiently large level area could not be had at CBA. It is on a tract now under lease by the Government for the use of the Diamond Ordnance Fuze Laboratory, and is within the Dahlgren air danger zone so that aircraft interference with the tracking operations will be minimized. It will be used as a prototype testing facility, a Minitrack-station team training facility, and finally as part of the whole satellite tracking complex.

The planning requirements for the tracking station to be located on the Island of Barbuda are in the final preparation stage. The utility of this station is intimately tied in with the launching vehicle trajectory, the range-safety firing-angle limitation, and the antenna beamwidth of the Minitrack station. The requirement for this station is based on the need to obtain an initial orbit measurement and also to verify that the Minitrack transmitter in the satellite is operating. Since the last two Vanguard test vehicles are complete prototypes of the final design, operation of the Barbuda station during these launches, starting in June 1957, is important. The present plan contemplates construction of this facility by the Bureau of Yards and Docks and operation by the AFMTC contractor, Pan American/RCA, under the technical supervision of Vanguard staff personnel.

THE LAUNCHING VEHICLE

Vehicle Specifications

During the period covered by this report performance parameters to be used in drawing up a Vanguard vehicle specification were determined. The vehicle requirements have been revised to conform to a new satellite package diameter of 20 inches (see SATELLITE section). A revised weight and performance summary, calculated to give a velocity margin of 1443 feet per second for a 300-mile projection altitude, is given in Appendix A. A trajectory based on these parameters was run and the most significant results are included in the summary. The Vanguard Launching Vehicle Design Specification (NRL No. 4100-1) has been completed and forwarded to the Glenn L. Martin Company.

The following subsystem specifications have been completed and are being reviewed:

NRL No. 4100-2	Launching vehicle antennas
GLM No. 924	Development specifications for liquid-propellant rocket engine for first stage of Vanguard launching vehicle
GLM No. 925	Development specification for liquid-propellant rocket engine package for second stage of Vanguard launching vehicle
GLM No. 926	Specification for solid-propellant rocket motor for third stage of Vanguard launching vehicle
GLM No. 1125	Subsystem specification for Vanguard guidance and control
GLM No. 1126	Specifications for VANGUARD static-firing and launching stand

GLM No. 1064	Development specification for three-axis gyro reference for Vanguard launching vehicle
GLM No. 1082	Design data requirements for Vanguard launching system

Evaluation of proposals for the third-stage solid-propellant motor was completed and negotiations initiated with the Allegany Ballistics Laboratory and the Grand Central Rocket Company for parallel developments through the development and qualification test phases. The revised performance requirements are:

Nominal Thrust	2350 lbs (60°F)
Maximum Burning Time	42 sec (60°F)
Velocity Required (vacuum)	13,500 ft/sec
Maximum Weight	430 lbs loaded (less attachment fittings)

Aerodynamics

A study of a new trajectory program for preflight prediction of test and launching vehicle trajectories is being pursued. This program simulates as closely as possible the flight of the actual vehicle. It takes into account a spherical rotating earth, Coriolis effects, and lift forces, and permits the specification of various pitch programs and aerodynamic parameters. The resulting predicted trajectories will be used for calculation of signal strengths and selection of the locations of the tracking stations, for setting range safety requirements, and for vehicle flight-path program adjustment.

Propulsion

Trajectories have been computed considering the effects of variations in powerplant performance, outages, flight-path errors, and fixed weights. These computations have shown the necessity for attaining specification values of powerplant and controls performance, outages, and fixed weights. A performance-improvement study program has been formulated and individual studies are under way. These include the following:

1. An investigation of the performance improvement possible through the use of a lox-fluorine oxidizer for the first-stage powerplant has been completed and is being discussed with contractors, and a test program will be proposed if it is agreed to be practical.

2. The advantage of using chilled RFNA as the oxidizer for the second-stage powerplant is being investigated.

3. The use of other more efficient oxidizers such as lox, lox-fluorine, perchloryl fluoride and fluorine trichloride for the second-stage powerplant is being studied.

4. Study of propellant utilization systems has been accelerated.

5. Thrust-chamber changes, such as a larger expansion ratio for the first-stage engine, are being studied.

6. The use of higher concentration H_2O_2 as the first-stage pump propellant is being investigated.

Specifications for the first-stage powerplant model, qualification test, and acceptance test have been submitted for review. A remote lox-servicing technique and design has been worked out which will permit filling, draining and topping through one fitting. The use of turbine exhaust gases for first-stage roll control is being considered, and valve design and pressure drops in ducts are being analyzed. A proposed fuel filling method is being reviewed. The testing of first-stage powerplant components continues.

The second-stage model specification is being reviewed. A mockup of this stage has been completed, and tools are being designed for the construction of a "spaghetti" cylinder Ignition studies, and studies of alternate pressurization methods (i.e., other than the use of hot helium) and ways of obtaining higher performance, are under way. A study of second-stage separation has also been started.

Flight-Path Control

Control-system analysis has continued with stability studies of the first-stage pitch-yaw system for launch, maximum q, burnout, Mach 0.58, Mach 2.425, and Mach 3.75 conditions. A similar system has been studied for second-stage control using preliminary second-stage missile dynamics data. Stabilization studies of the second-stage pitch-yaw jet system have been conducted using a single lead circuit, and similar studies have been made of the second-stage roll jet system using a single lead circuit and a "rate-squared" compensation network. The breadboarding of the pitch-yaw amplifier for Test Vehicle 1 has been completed. Proposals for magnetic-amplifier autopilots have been received.

Upon the basis of the latest third-stage proposals, moments of inertia and center of gravity as functions of time were calculated preparatory to computing the spin required for gyro-stability of the third stage.

Design

First- and second-stage spatial mockups have been released for manufacture. The design of a dynamic model of the first-stage powerplant installation and rocket tail section has been completed. Approximately 50 percent of all major structural layout and design of the first stage is now complete and about 10 percent of the associated detail drawings are finished.

The nomenclature of test vehicles has been revised: Viking 13 has been designated TV-0; Viking 14, TV-1, and subsequent test vehicles, TV-2, TV-3, TV-4, and TV-5.

Instrumentation

During January investigative trips and discussions provided clarification of a number of details of the launching vehicle instrumentation program. The following discussions were held at PAFB:

1. A discussion of the Vanguard requirements for a launching and static-firing complex—A detailed investigation was made of the feasibility of using an aircraft area launching site.

2. Several discussions of the Vanguard instrumentation plan with RCA — During these talks PAFB stated that it would be able to tape record pwm/fm transmissions chain wide. Real-time recording requirements beyond Cape Canaveral were given to PAFB and installational requirements for closed-loop telemetering checkout stations were discussed also. The issue of possible requirements for tape recording of Dovap information was raised by NRL in view of the high velocities anticipated.

3. Discussions with the AFMTC range safety personnel to clarify mutual problems and information requirements — The AFMTC standard fuel cutoff and destruct sequence was obtained. In all discussions of range safety, NRL has consistently stated that it can afford to have only two range safety receivers in the mission vehicle — one in the first stage and one in the second.

A tentative frequency allocation was obtained from the PAFB frequency coordinator as follows:

Test Vehicle 0

Telemetering frequencies:	pwm/fm - 232.0 Mc ppm/am - 227.5 Mc ppm/am - 224.0 Mc

All vehicles

Range safety frequency:	410.0 Mc
S-band beacon frequencies:	receive - 2900 Mc transmit - 2940 or 2950 Mc

All vehicles except TV-0

Telemetering frequencies:	pwm/fm - 232.0 Mc ppm/am - 229.5 Mc ppm/am - 224.0 Mc fm/fm - 222.0 Mc

The close spacing between the pwm/fm and ppm/am assignments will require extensive field tests at WSPG to determine whether or not any mutual interference will result. Tests will also be conducted regarding optimum minimum spacing of ppm/am and fm/fm transmitters. The AFMTC Dovap frequencies are:

ground transmit - 36.94 Mc

ground receiver - 73.88 Mc

The following trips were made to other agencies during January and February:

1. A trip to RCA at Moorestown, N. J., to attend preliminary planning discussions for forthcoming tests on the AN/FPS-16(XN-1) radar.

2. Several visits to the Bureau of Aeronautics with regard to the AN/FPS-16 radar and range safety equipment.

3. A trip to Elsin Electronics Company to monitor progress on the ppm/am telemetering ground stations. As a result of investigative work being carried out at NRL several changes planned by Elsin were stopped and alternative circuits and tube complements provided.

4. A trip to the Redstone Arsenal to discuss missile antennas and performance of Dovap and AN/ARW-59 range safety receivers.

The following procurements were initiated during the month of January:

One set of pwm/fm transmitting equipment for mockup and test

Ten T-10 Dovap transponders

Test equipment for ppm/am ground stations

The following equipment was received:

Frequency standard for ppm/am station Beacon test equipment

ARN/59 receiver and signal generator

THE SATELLITE

Configuration and Design

The configuration of the satellite has now been established as a 20-inch diameter sphere instead of the 30-inch sphere previously under consideration. The total weight of 21.5 pounds has not changed. Preliminary structural design has begun in order to determine whether or not structural weight estimates can be met and to develop several possible arrangements. Strength and fabrication are the main consideration at this time. Indications are that the structural weight will certainly not exceed the estimate of 11.5 pounds.

Design work is based on using a magnesium-thorium alloy (HK-31) for the sphere and internal members. This alloy has greater strength and less weight than suitable aluminum alloys at the anticipated maximum orbital temperature of 400°F. The HK-31 is available in the required size and thickness, and fabricating techniques are well established.

Work is continuing on the determination of the coefficients of emissivity and reflection for HK-31. The reflection coefficient, it is believed, will be acceptable. To effect an acceptable coefficient of emissivity, the surface probably will be coated with 40 to 50 microinches of silicon monoxide, which does not appreciably affect the reflection coefficient. The coating is applied in a vacuum chamber; chambers of sufficient size are available.

The structural design is being based on a 30-g steady acceleration. An additional 30 g due to vibration is being assumed, and efforts are being made to refine this assumption on vibrational loading by means of data from similar solid-propellant rockets.

Investigation of separation methods is continuing. A combination powder delay and separating charge, contained in a hermetically sealed unit, seems most desirable. However, problems still remain in the design of this unit to meet requirements of space, burning time, force, and stroke.

Instrumentation and Tracking

Contracts

Contracts for the development of the ground antenna arrays for the Minitrack system have been let, to provide antennas by 1 June 1956. These contracts, for seven antennas each, were let to two contractors making different types at different costs. The first contractor, the D. S. Kennedy Company of Cohasset, Massachusetts is making an array of slots that may increase the north-south dimensions of the fan beam from 90 degrees to over 110 degrees, thereby increasing the latitude coverage of a single Minitrack station by over 40 percent. The second contractor, the Technical Appliance Corporation of Sherburne, New York, is providing a dipole array along more conventional lines using standard components and techniques to a large extent. The cost of this antenna will probably be about 40 percent of that of the Kennedy unit. If it is not suitable for the Minitrack application it will be suitable as a telemetering antenna, which does not require the stringent phase contour of the tracking antennas. This antenna will also be applicable to the simplified Minitrack system.

Schedule

A complete Minitrack station will be in operation at the Blossom Point site by mid-June 1956 using the final antenna arrays. The initial setup, using small antennas, will be completed by mid-May.

The general schedule for development of the Minitrack system is as follows:

1.	Operation of Test and Evaluation Facility at Blossom Point to start	1 June 1956
2.	Test and evaluation, and modification of NRL prototypes for ground electronics, against balloons and planes	June through October 1956
3.	Phasing-in contractor for indoctrination and preliminary mechanical design for ground station electronics	August 1956
4.	Production of final ground station units to start	1 October 1956
5.	Training of senior field crew members at Blossom Point to start	1 March 1957
6.	Delivery of initial ground stations in trailer vans, ready for field tests at Blossom Point	1 May 1957
7.	Completion of overseas sites, ready for occupancy by technical field crews	1 July 1957
8.	Shipment of initial station units, complete with all ground-station components and operating crews	1 July 1957
9.	Completion of all operating sites; field crews and equipment installed; commencement of shakedown operations	1 September 1957
10.	Initial tracking operations with satellite	1 October 1957

Antenna Calibration

Tests of methods for calibrating, or boresighting, the ground antenna systems are being conducted, primarily to evaluate tethered balloons or "Kitoons" for this application. The results are so favorable that the use of free balloons launched at some distance from a Minitrack station has now been abandoned. These tests are being made with a trial simplified Minitrack installation at Blossom Point. A plane has been made available exclusively to this project.

Alternate Stations

Evaluations of alternate Minitrack station locations are being conducted. These evaluations are based on the following four objectives for the Minitrack operation, in the order of their relative importance:

1. Proof that a satellite has been established in an orbit

2. Acquisition for optical tracking units

3. Provision of telemetering from the satellite

4. Determination of an orbit suitable for geodetic measurements

Effect of the Ionosphere

A series of evaluation tests to determine the magnitude of the effect of the ionosphere on a Minitrack system is being scheduled, using Aerobee and Aerobee-Hi rockets. Two simulated satellite packages will be flown in Aerobee-Hi rockets against a two-axis simplified Minitrack ground installation. These flights will provide much needed ionospheric data not now available for system evaluation. A similar flight in an Aerobee using a 46-Mc signal will provide information to about 100 miles. These experiments will be continued in the Vanguard test vehicle series in order to give measurements up to altitudes of several hundred miles.

Transmitting Frequencies

Authorization has been granted for a Minitrack operating frequency of 108.00 Mc in the satellite, and a Minitrack telemeter turn-on frequency of 138.06 Mc to be transmitted from the ground. The latter is to be held in a confidential classification to prevent possible false turn-on of the satellite equipment by unauthorized groups.

Choice of Satellite Components

Both transistor and subminiature tube developments for the Minitrack satellite package are now being conducted on an accelerated basis by the Transistor and Avigation Branch of NRL. These developments are to be completed by mid-August 1956, at which time an evaluation of both types, and final selection of the type to be included within the satellite package, will be made.

Two types of antenna are being investigated. A telescoping powder-erected antenna has the desirable characteristics of light weight and rigidity. Antennas of this type are being built by the Diamond Ordnance Fuze Laboratory for operational tests in several

Aerobee rockets. A prototype spring antenna-erection mechanism has been built. This mechanism is desirable because of simplicity and retractability, but centrifugal forces may preclude its use. The choice of antenna type cannot be made until all requirements, mechanical and electrical, are known.

Scientific Experiments

A formal proposal for the scientific experiments to be included in the first Project Vanguard satellites has been presented to the Technical Panel on the Earth Satellite Program. The proposal includes a short description of the satellite as presently envisioned and an outline of the experiments considered necessary and feasible. In addition, various models for the satellite vehicle are being considered to permit flexibility in the payload available for scientific experiments. A recommended science program has been presented to the Project Director by the Science Program Coordinator and the following projects have been authorized:

Minitrack system development

Telemetering development

Studies to insure visibility of the satellite

Design and development of instrumentation for the Lyman-alpha experiment proposed to the Satellite Panel

Design and development of instrumentation for environmental studies in the satellite

An environmental testing program for the satellite and for all equipment to go into the satellite

Development work on the approved programs is progressing as rapidly as firm specifications become available. Areas in which progress may be reported are:

1. Visual Acquisition and Tracking

   Two NRL Memorandum Reports have been written: No. 552, "The Visibility of an Earth Satellite," and No. 560, "Optical Acquisition and Tracking of the Satellite."

2. Visibility Studies

   Equipment is being built to determine more exactly the visibility of the satellite.

3. Reflectance of the Satellite

   Equipment is being constructed to measure the effective reflectance of scaled-down models of the satellite having various surface finishes.

4. Components

   Component development for the Lyman-alpha experiment includes the study of detector tubes to withstand great temperature changes. Two designs are currently being studied.

5. Environmental Studies

   Data has been collected for use in the design of the simulated-environment testing facility.

6. Telemetering

   Preliminary specifications for telemetering have been written and development of satisfactory circuitry is in progress.

COMPUTATION

Vehicle Performance Data

All launching-vehicle performance data, including those from the telemetering and range instrumentation systems, will be used in computations by NRL for evaluating the performance of the launching vehicle after each flight.

Telemetering Data

Reduction of some of the telemetering data will be the responsibility of NRL (see Project Vanguard Report No. 1, p. 32). A preliminary survey has been made of possible subcontractors to do this work by manual and semiautomatic means. Automatic equipment for this purpose is also continuing under consideration.

Orbital Data

The mathematical formulation of the earth-satellite problem is currently being developed by Project Vanguard to use the Minitrack observations to the best advantage and to include orbital perturbations due to the shape of the earth and to the density of the air (when applicable). Optical observations will also be taken into consideration since they will be used too, when available. A set of constants to describe the satellite orbit will be calculated so that any observer in the world may use them to predict passage with respect to his observing location. In addition, there will be certain favored observers around the world, for whom detailed predictions will be made. These favored observers are expected to include the Minitrack stations, the official IGY optical observing stations, the principal astronomical observatories of the world, and the major cities of the world. The calculations for optical observations need be made only for those locations having twilight conditions and favorable location for observing the satellite. For the IGY optical stations, the minimum prediction data to be computed will be time of meridian passage, zenith distance, angular velocity, and location of a favorable acquisition direction before meridian passage. For populated areas, a predicted time-history of the sub-satellite point on the earth's surface and the path width of visibility will suffice. Predictions will be made as far into the future as the accuracy of the input data will allow.

Within twenty minutes of the meridian passage of the satellite over a Minitrack station, that station is expected to provide three sets of data, each set consisting of two angles defining the direction of the satellite at the measured time (see Project Vanguard Report No. 1, p. 42). These data will be transmitted to a central Government communications center located at Washington, D. C., and then retransmitted by Government-furnished Teletype to a computer facility in the area. Because of the necessity for rapid calculation of the satellite orbit, particularly for prediction purposes, the computer must have sufficient speed to complete a multiplication operation in 300 microseconds or less. On the basis of preliminary contacts with the computer industry, it appears feasible to rent this computer facility on a demand basis from a contractor, who can use the facility for his own purposes when it is not being used by Project Vanguard. Since a computer must be continuously available and operational 24 hours a day seven days a week for a period of at least two weeks after a successful satellite launching, the contractor would also make a second computer of the same type available concurrently to insure reliable computation throughout this period. The second computer could be located away from Washington, D. C. and would be used only if the primary computer failed. Communications between the two computers would be furnished by the contractor, and switching between them would be accomplished within 5 minutes.

A request for a bid on these computational facilities will be released during February 1956, and it is expected to have the contract established the following month. It is important to have the contract completed as soon as possible so that a computer of the type to be used during the satellite launching attempts can be available for preliminary work, including error studies and "dry" runs to insure successful operation at the time of an actual launching.

* * *

APPENDIX A
Vanguard Vehicle Performance Summary

The values in this appendix represent the launching vehicle design status as of January 1956. Individual values are expected to change from week to week as design, construction, and tests proceed. The performance summary will be kept current in these reports.

Velocity

Total satellite velocity:	26,477 ft/sec
Excess over circular orbital velocity at 300 miles altitude:	1,443 ft/sec

Fundamental Parameters

The fundamental parameters are given in the following table.

Stage	Mass Ratio	Stage Ratio	Specific Impulse (sec)
1	0.877	0.789	253.5
2	0.756	0.899	278
3	0.815	1.000	247

The mass ratios shown are the propellant mass ratios of the given stage alone.

The stage ratio is defined as the ratio of the weight of a given stage alone to the weight of the complete stage, including all the stages it carries.

The specific impulses shown are the sea-level value for the first stage, and the vacuum values for the second and third stages.

Performance Data

First Stage

Weight data

Gross weight of vehicle (lbs)	22,600
First stage alone	
Total stage weight (lbs)	17,830
Total burnout weight (lbs)	2,198
Total dry weight (lbs)	1,782
Structure (lbs)	680
Powerplant (lbs)	850
Controls and guidance (lbs) (including hydraulic fluid)	110
Electrical system (lbs)	57
Instrumentation (lbs)	39
Telemetering and command receiver (lbs)	46

Propulsion data

Specific impulse at sea level (sec)	253.5
Thrust at sea level (lbs)	27,000
Nozzle exit area (in^2)	176

Aerodynamic data

Frontal area (ft^2)	13.5

Trajectory data

Burnout velocity (ft/sec)	5,605
Burnout acceleration (ft/sec^2)	116
Burnout acceleration (g)	3.6
Burning time (sec)	147

Second Stage

Weight data

Total weight of second and third stages (lbs)	4,770
Second stage alone	
Total stage weight (lbs)	4,286
Total burnout weight (lbs)	1,047
Total dry weight (lbs)	973
Structure (lbs)	134.0
Powerplant (lbs)	458.0

Controls and guidance (lbs)	198.7
Electrical system (lbs)	85.0
Instrumentation (lbs)	28
Telemetering and command receiver (lbs)	69.3

Propulsion data

Specific impulse at altitude (sec)	278
Thrust at altitude (lbs)	7,500
Nozzle exit area (in^2)	306

Aerodynamic data

Frontal area (ft^2)	6.1

Trajectory data

Burnout velocity (ft/sec) (including earth's rotational velocity)	14,818
Burnout acceleration (ft/sec^2)	147
Burnout acceleration (g)	4.6
Burning time (sec)	120
Apogee altitude (mi)	300
Apogee velocity (ft/sec)	13,072

Third Stage

Weight data

Total weight (lbs)	484
Total burnout weight (lbs)	90
Payload (lbs)	21.5
Powerplant (lbs)	55
Miscellaneous items (lbs)	12.5

Propulsion data

Specific impulse at altitude (sec)	247
Thrust at altitude (lbs)	2,350

Trajectory data

Velocity contribution (ft/sec)	13,405

* * *

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